REPLACEMENT SHEET

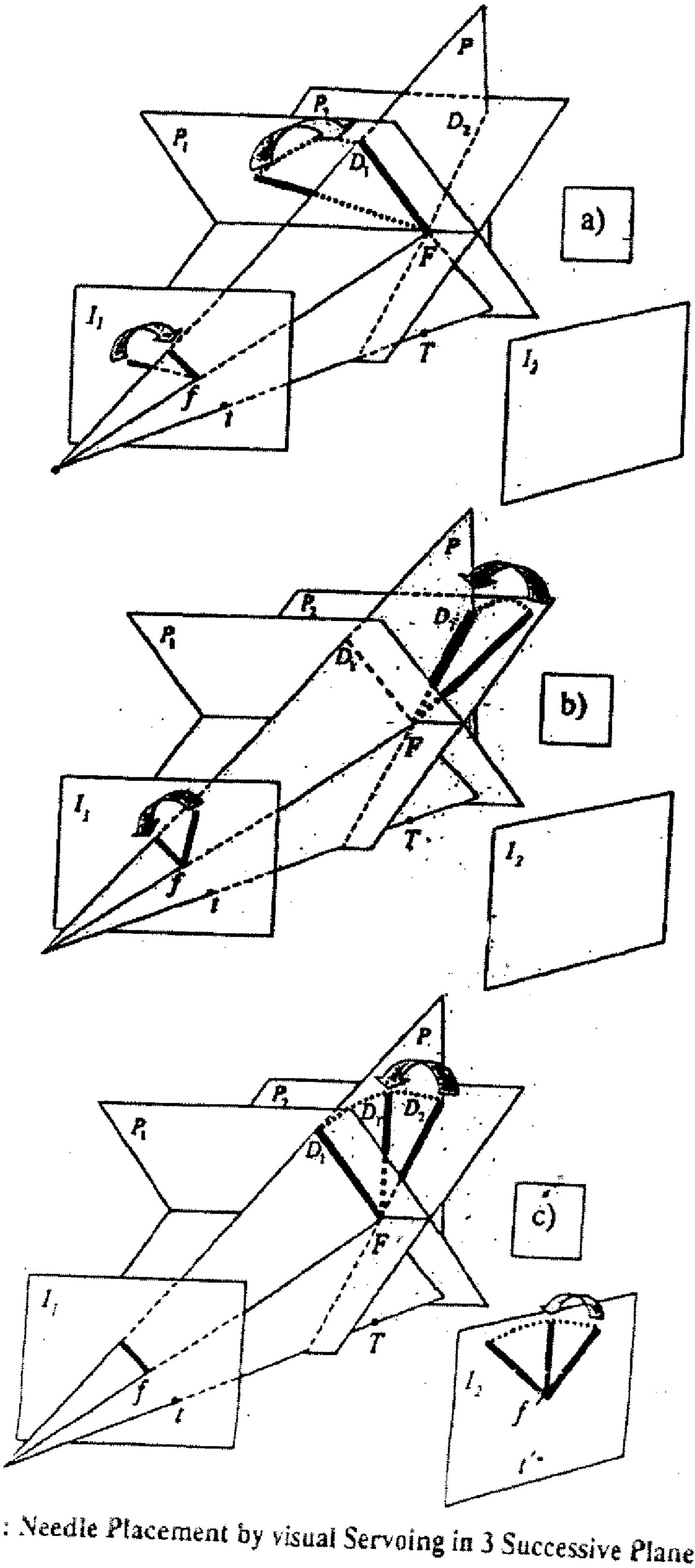


Fig. 1: Needle Placement by visual Servoing in 3 Successive Planes using 2 views

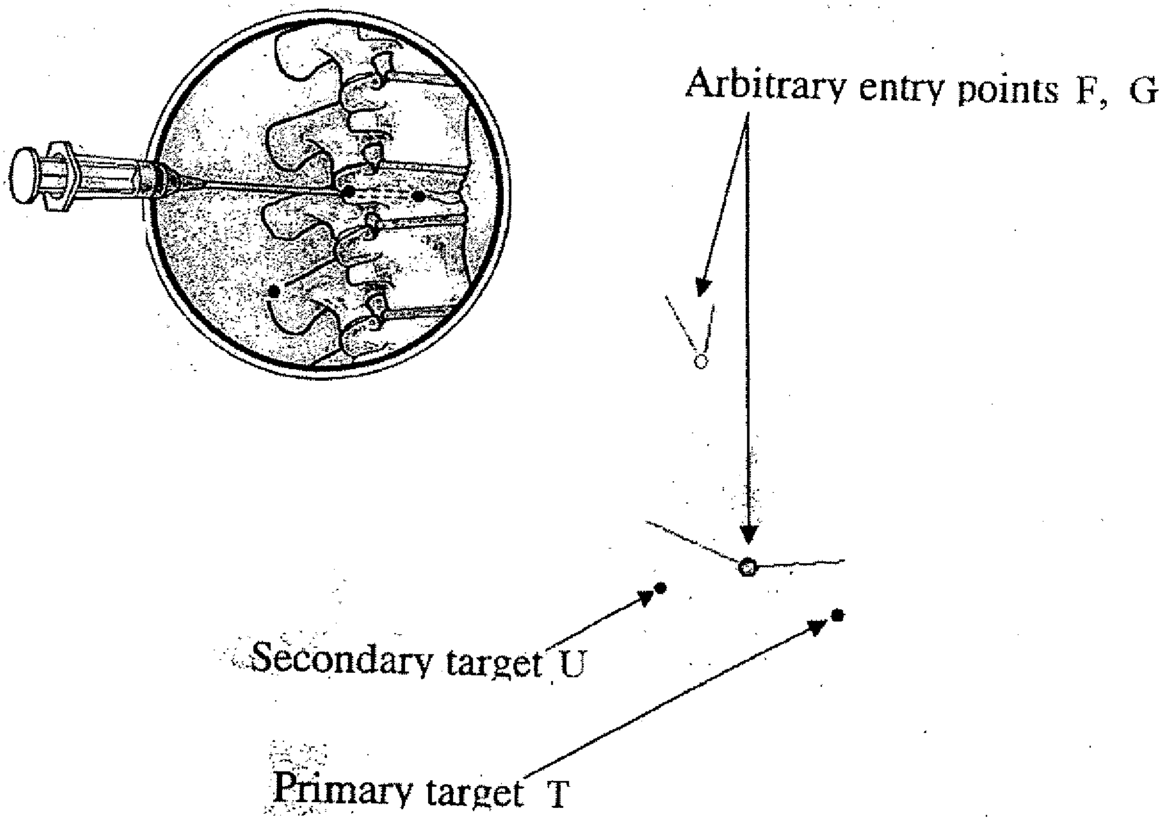
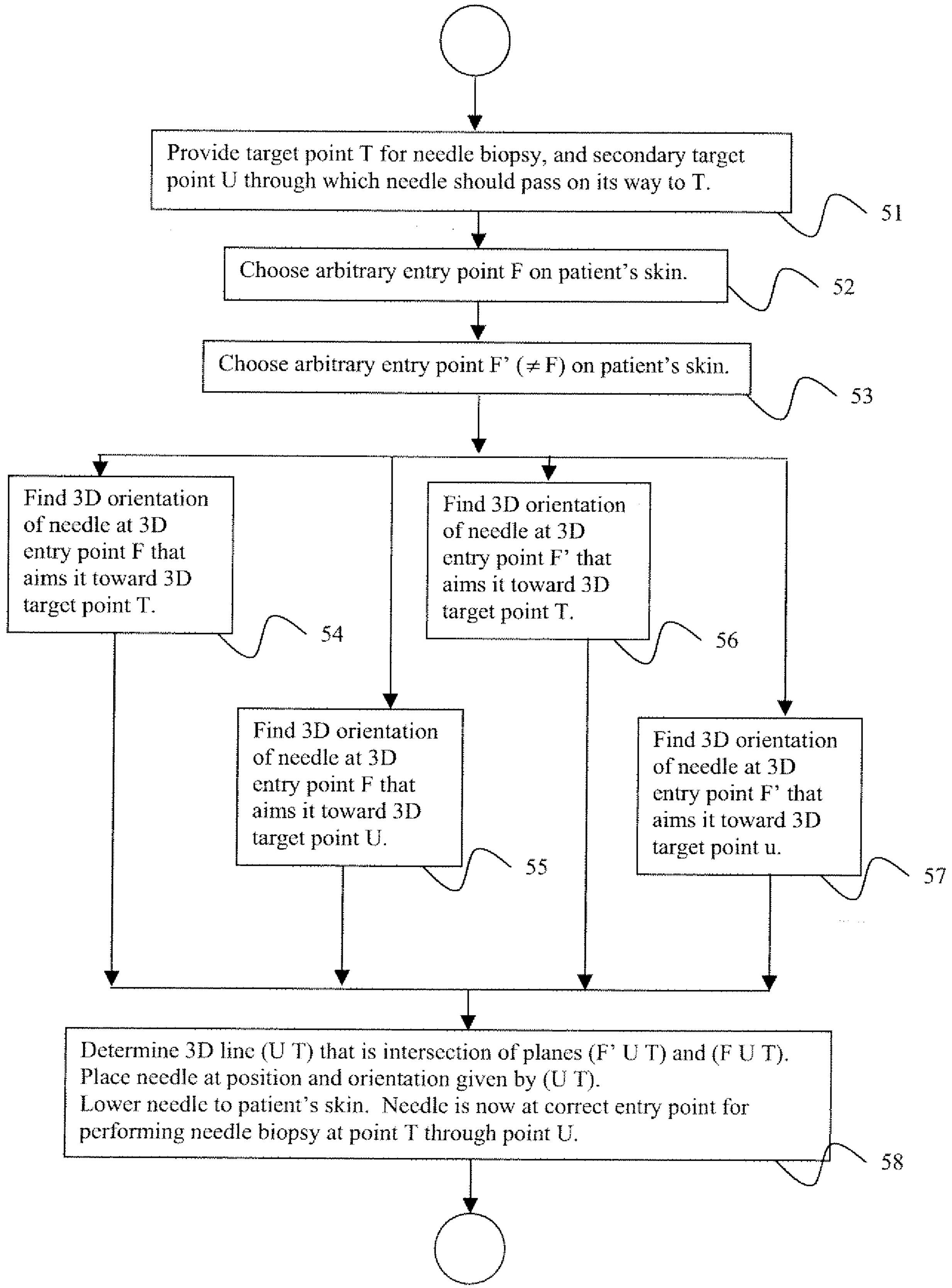


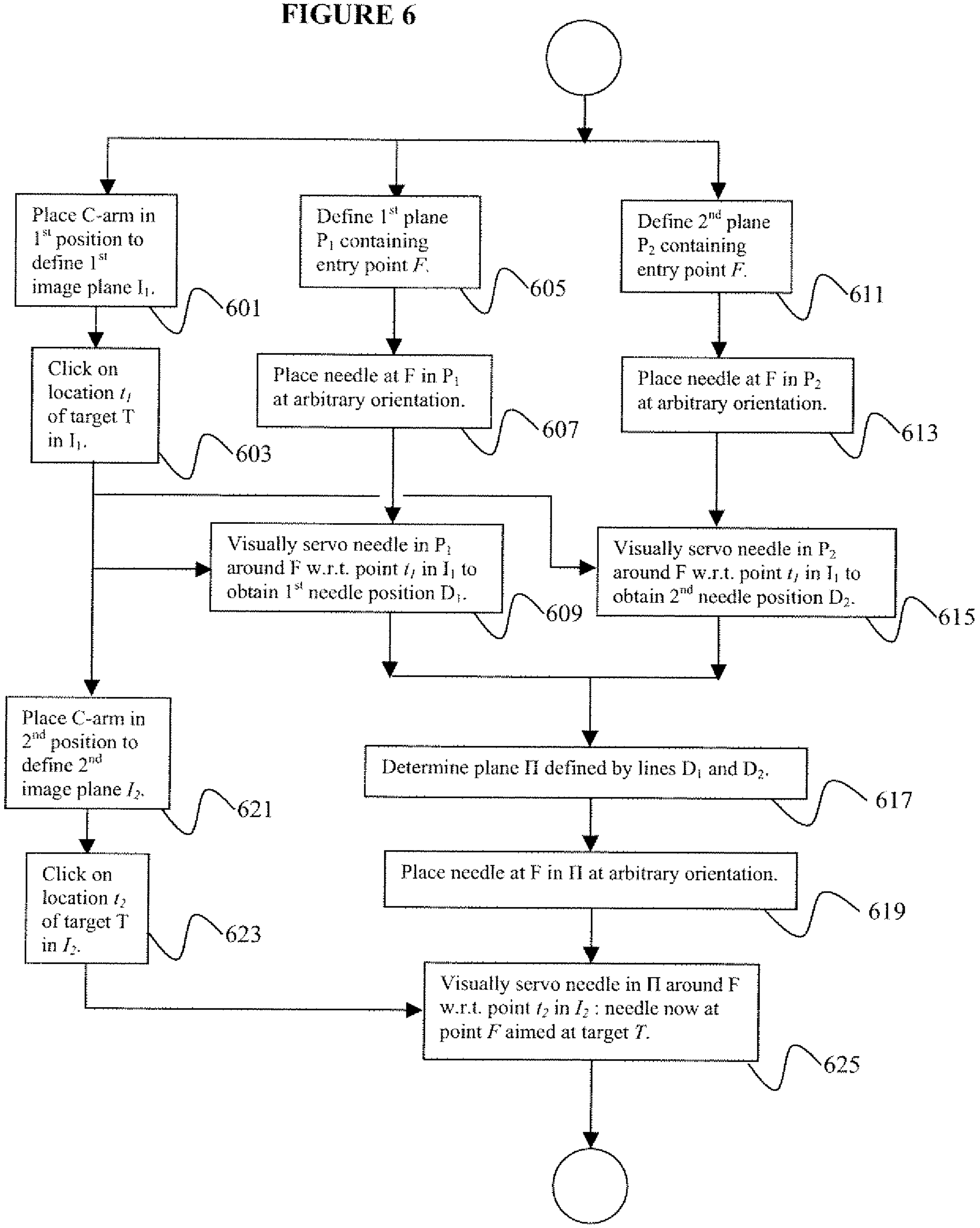
Fig. 4 Best entry point to reach one target by passing through secondary target. It can be found by first orienting the needle to the targets from 2 arbitrary entry points

FIGURE 5


Provide target point T for needle biopsy, and secondary target point U through which needle should pass on its way to T.
51
Choose arbitrary entry point F on patient's skin.
52
Choose arbitrary entry point F' (≠ F) on patient's skin.
53
Find 3D orientation of needle at 3D entry point F that aims it toward 3D target point T.
54
Find 3D orientation of needle at 3D entry point F' that aims it toward 3D target point T.
56
Find 3D orientation of needle at 3D entry point F that aims it toward 3D target point U.
55
Find 3D orientation of needle at 3D entry point F' that aims it toward 3D target point u.
57
Determine 3D line (U T) that is intersection of planes (F' U T) and (F U T). Place needle at position and orientation given by (U T). Lower needle to patient's skin. Needle is now at correct entry point for performing needle biopsy at point T through point U.
58

REPLACEMENT SHEET

FIGURE 6


Place C-arm in 1st position to define 1st image plane I1.
601
Click on location t1 of target T in I1.
603
Define 1st plane P1 containing entry point F.
605
Place needle at F in P1 at arbitrary orientation.
607
Visually servo needle in P1 around F w.r.t. point t1 in I1 to obtain 1st needle position D1.
609
Define 2nd plane P2 containing entry point F.
611
Place needle at F in P2 at arbitrary orientation.
613
Visually servo needle in P2 around F w.r.t. point t1 in I1 to obtain 2nd needle position D2.
615
Determine plane Π defined by lines D1 and D2.
617
Place needle at F in Π at arbitrary orientation.
619
Place C-arm in 2nd position to define 2nd image plane I2.
621
Click on location t2 of target T in I2.
623
Visually servo needle in Π around F w.r.t. point t2 in I2 : needle now at point F aimed at target T.
625